A radiographic analysis of anterior-posterior translation in total knee arthroplasty

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Abstract We performed radiological analyses to examine the relationship between the knee flexion angle and the anteroposterior translation movement relative to the prosthetic components (NexGen type) after total knee arthroplasty (TKA). Cruciate-retaining (CR) type TKA was performed in 12 knees with osteoarthritis (OA) and 9 knees with rheumatoid arthritis (RA) in which no posterior cruciate ligament (PCL) tear was present. Posterior-stabilized (PS) type TKA was performed in 7 OA knees and 7 RA knees in which the PCL was defective or resected. The measurements were performed according to the methods of Watanabe. The contact point ratio (percentage) was calculated by dividing the distance to the contact point (CP; the closest point of contact between the femoral and tibial components) by the anteroposterior length of the tibial component. After TKA, the CP at full extension was positioned more posteriorly than in the normal knee both under weight-bearing and non-weight-bearing conditions. Except for the RA knees in the PS group, the CP translated anteriorly in the early phase of flexion and then posteriorly. Under weight-bearing conditions, the posterior translation occurred earlier and was smaller in magnitude. For RA knees in the PS group, the CP moved gently posteriorly right from the beginning.

Key words Total knee arthroplasty · Posterior cruciate ligament · Radiography · Anteroposterior translation

Introduction

Total knee arthroplasty (TKA) is commonly performed for the treatment of severely deteriorated osteoarthritic and rheumatoid knee joints, and satisfactory clinical results have been reported. However, many modifications are still being tried to acquire physiological roll-back movement in the knee joint prosthesis. The posterior cruciate ligament (PCL) plays an important role in roll-back movement in the knee joint, allowing deep flexion. The PCL is also associated with knee stability. Retaining the PCL in TKA has been reported to achieve good results. However, a controversy remains as to whether the PCL should be preserved or excised. In this study, we performed a radiographic analysis of the displacement of the contact point between the femoral component and the tibial component during knee motion in PCL-retaining TKA and PCL-resected TKA, and examined the translation of the contact point.

Subjects and methods

NexGen type (Zimmer, USA)
PCL-retaining TKA (CR; cruciate-retaining type). The radii of curvature at the medial and lateral condyle of the femoral component were different to achieve axial rotation, and roll-back movement was achieved by the retained PCL.

PCL-resecting TKA (PS; posterior-stabilized type). The radii of curvature of the femoral surface were made smaller than those in the CR type. These were designed to improve rotation and stability. Roll-back movement was achieved by a post and cam mechanism.

Subjects

Nineteen knees in 14 patients with OA and 16 knees in 10 patients with RA were studied. The backgrounds of the patients are shown in Table 1. Two types of NexGen (Zimmer, USA) prostheses were used. The cruciate-retaining (CR) type was used in 12 OA knees and 9 RA
knees in which no PCL tear was confirmed at surgery (CR group). The posterior-stabilized (PS) type was used in 7 OA knees and 7 RA knees in which the PCL was found to be defective or was excised during surgery (PS group). The average age at surgery was 74.0 years in the OA group and 67.5 years in the RA group. Follow-up duration was 7.4 months on average after surgery in the OA group and 7.3 months in the RA group.

Method of measurement

Radiography was performed according to the method of Watanabe.\(^1\) The subject was placed in a lateral decubitus position on a fluoroscopic table in a non-weight-bearing state. From a fully extended position, the knee was flexed in increments of approximately 10°. The examiner moved the knee manually to ensure that the femoral component was in an accurate lateral view on the fluoroscopic image while the range of motion was performed. In the OA patients (8 knees in the CR group, 7 knees in the PS group), radiographs were also taken under weight-bearing conditions. While standing on both legs, the patient was asked to shift the body weight onto the leg to be measured, and the knee was bent gradually from an extended position. Radiographs were taken at approximately 10° flexion intervals while the examiner checked that the femoral component was in an accurate lateral view.

Radiographic image analysis

The method of radiographic image analysis is shown in Fig. 1. The contact point was taken as the point of closest contact between the femoral component and the tibial component. The contact point ratio (CPR) was calculated by dividing the distance from the anterior edge of the tibial component to the contact point by the anteroposterior length of the tibial component. The flexion angle was not calculated from the bone axis, but was measured as the angle formed between the femoral component and the tibial component. Because there were differences in flexion angle among the knees, the data were expressed graphically, using fourth-degree regression curves.

Results

Clinical results

The preoperative and postoperative ranges of motion and scores according to the Japanese Orthopaedic Association criteria of knee function (JOA score) for OA patients and RA patients are shown in Tables 2 and 3, respectively.

As for the preoperative range of motion, the average extension and flexion in OA patients were \(-15.0°\) and \(119.2°\), respectively, in the CR group, and \(-16.7°\) and \(110.8°\) in the PS group. The average JOA score was 43.8 (range, 35 to 60) in the CR group and 43.3 (range, 40 to 50) in the PS group. After surgery, the average extension and flexion in OA patients were \(-3.8°\) (range, 0° to 10°) and \(110.8°\) (range, 70° to 140°), respectively, in the CR group, and \(-0.8°\) (range, 0° to 5°) and \(110.0°\) (range, 90° to 120°) in the PS group. The average JOA score was 77.1 (range, 65 to 95) in the CR group and 79.2 (range, 70 to 85) in the PS group.

Table 1. Background of subjects

| Patients | 19 Knees of 14 OA patients | 16 Knees of 10 RA patients |
| Sex | 7 men, 7 women | All women |
| TKA type | CR type: 12 knees (6 in men, 6 in women) | PS type: 7 knees (1 in a man, 6 in women) |
| Age at surgery | Average, 74.0 years (range, 59–85 years) | Average, 67.5 years (range, 59–76 years) |
| Follow-up period | Average, 7.4 months (range, 1.4–22.6 months) | Average, 7.3 months (range, 2.4–16 months) |

TKA, Total knee arthroplasty; OA, osteoarthritis; RA, rheumatoid arthritis; CR, cruciate-retaining; PS, posterior-stabilized

Table 2. Clinical results (OA group)

<table>
<thead>
<tr>
<th>Knee range of motion</th>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>PS</td>
</tr>
<tr>
<td>Extension</td>
<td>(-15.0°) ((-60°) to 0°)</td>
<td>(-16.7°) ((-30°) to 0°)</td>
</tr>
<tr>
<td>Flexion</td>
<td>119.2° (95° to 130°)</td>
<td>98.3° (85° to 120°)</td>
</tr>
<tr>
<td>JOA score</td>
<td>43.8 (35 to 60)</td>
<td>43.3 (40 to 50)</td>
</tr>
</tbody>
</table>

Figures in parentheses show ranges

JOA, Japanese Orthopaedic Association

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